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RESEARCH

Innovative approaches to concrete health monitoring: wavelet transform and artificial intelligence models

Soumyadip Das[1] · Aloke Kumar Datta[1] · Pijush Topdar[1] · Apurba Pal[1]

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Abstract
The health monitoring of concrete structures is of principal concern to avoid major accidents. Presently, many large-scale structures have been constructed throughout the world and in India. Therefore, there is an urgent need for sensor-aided research to keep all these large infrastructural facilities for the long life in an uninterrupted manner. As per the available literature, the Acoustic Emission (AE) sensor data and its deployment for the development of an artificial intelligence (AI) model is most suitable for health monitoring of these types of structures. Researchers have used the signal processing method. However, the AI models have significantly reduced the effort as well as errors in the computation process. In this study, an experimental investigation is done using the AE system for data generation. A good number of concrete slabs of different grades were cast and used for generating data deploying the Pencil Lead Break (PLB) approach. The generated data was utilized for finding the damage location using the WT method and AI models. The developed AI model is more effective in the health monitoring of concrete structures as the error in calculation is less as compared to the WT method. The model is also validated by identifying the damage source (simulated) in the concrete slab. This approach can be utilized for real-time health monitoring of large-scale concrete structures comprised of slab-like components without any interruption. Results show promising trends for further research for making the health monitoring process in wider application of civil engineering structures.

Keywords Concrete structures · Structural health monitoring · Acoustic emission · Wavelet transform · Artificial intelligence · ANN · SVM

Introduction

Large-scale concrete structures constitute fundamental elements of contemporary infrastructure, playing an indispensable role in national development endeavors. Preserving the structural integrity and safety of the infrastructures without hampering normal function stands paramount to pre-empting potential hazards and sustaining uninterrupted traffic flow. Structural health monitoring (SHM) emerges as a pivotal approach geared towards ensuring the safety and upkeep of such structures. Within the realm of SHM, a spectrum of non-destructive techniques (NDTs) has garnered increasing attention over recent decades. Among these techniques, Acoustic Emission (AE) monitoring aided by the Artificial Intelligence (AI) technique has emerged as a particularly valuable method for evaluating structural health and discerning incipient damage in concrete components. The concept of acoustic emission encompasses the detection and analysis of transient stress waves resulting from the abrupt release of energy within a material subjected to a load (Sengupta et al., 2015). These emissions offer invaluable insights into the structural behavior of concrete elements, facilitating real-time monitoring of crack initiation and propagation (Mirgal et al., 2020). By scrutinizing AE signals, engineers can pinpoint critical areas of distress and schedule timely maintenance interventions to mitigate the risk of structural

✉ Soumyadip Das
sd.16ce1311@phd.nitdgp.ac.in

Aloke Kumar Datta
dattarec@yahoo.com

Pijush Topdar
ptopdar.ce@nitdgp.ac.in

Apurba Pal
ap.21ce1102@phd.nitdgp.ac.in

[1] Department of Civil Engineering, National Institute of Technology Durgapur, Durgapur 713209, India

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